FOREST QUADRAT STUDIES AT THE ARBORETUM AND OBSERVATIONS ON FOREST SUCCESSION

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Recently some of the general changes, based on time-lapse studies, occurring in the Forest Preserve of the Missouri Botanical Garden Arboretum, at Gray Summit, were reported on.[1] However, this report covered the Forest Preserve as a whole, and the complex structure of the forest growth was not expressed. Quadrat studies of critical tree associations were begun concurrently with the more general mapping of forest growth, with a view toward acquiring data on the specific changes taking place on smaller, accurately plotted sites which might be expected to lead to an understanding of the problems of forest tree associations in that area. In this paper the changes which have occurred in a lapse of twelve years are reported for three quadrats, and a fifteen-year record is available for one quadrat.

Quadrats, 15 × 15 meters, were selected in areas typical of the several recognized forest-tree associations. All corners of the quadrats were marked with painted iron stakes to insure their accurate location. A grid of stout twine was established at three-meter intervals in order to plot the trees. Approximate trunk diameters (DBH) were measured in inches so that relative dominance of forest species and their growth rate might be recorded.[2]

Quadrat in the Oak (Quercus sp.*) Coppice.*—This quadrat (figs. 1 and 2), representing a 15-year sequence, was established in an oak coppice where stump sprouts indicated that White Oak *(Quercus alba)* was the dominant tree. Soil of this area is of the Union Silt Loam and lies upon the "cotton rock" phase of the Cotter Formation of dolomitic limestones. Exposure is to the east, and the quadrat is near the summit of the ridge. The early map of the quadrat shows a more "open" aspect. At that time abundance of light encouraged the White Oaks to develop a low and spreading crown. The Red Cedar *(Juniperus virginiana)*, Redbud *(Cercis canadensis)*, Walnut *(Juglans nigra)*, Shingle Oak *(Quercus imbricaria)*, Mocker-nut Hickory *(Carya tomentosa)*, and Persimmon *(Diospyros virginiana)* assumed similar growth habits. There were a number of Slippery Elms *(Ulmus fulva)* seedlings, and a small Sycamore *(Platanus occidentalis)* in rather poor condition.

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[1] Beilmann, A. P., and Brenner, L. G. The changing forest flora of the Ozarks. Ann. Mo. Bot. Gard. 38:283–291. 1951.

[2] Species names mentioned in this report are according to Alfred Rehder's, Manual of Cultivated Trees and Shrubs, 2nd ed. 1940.

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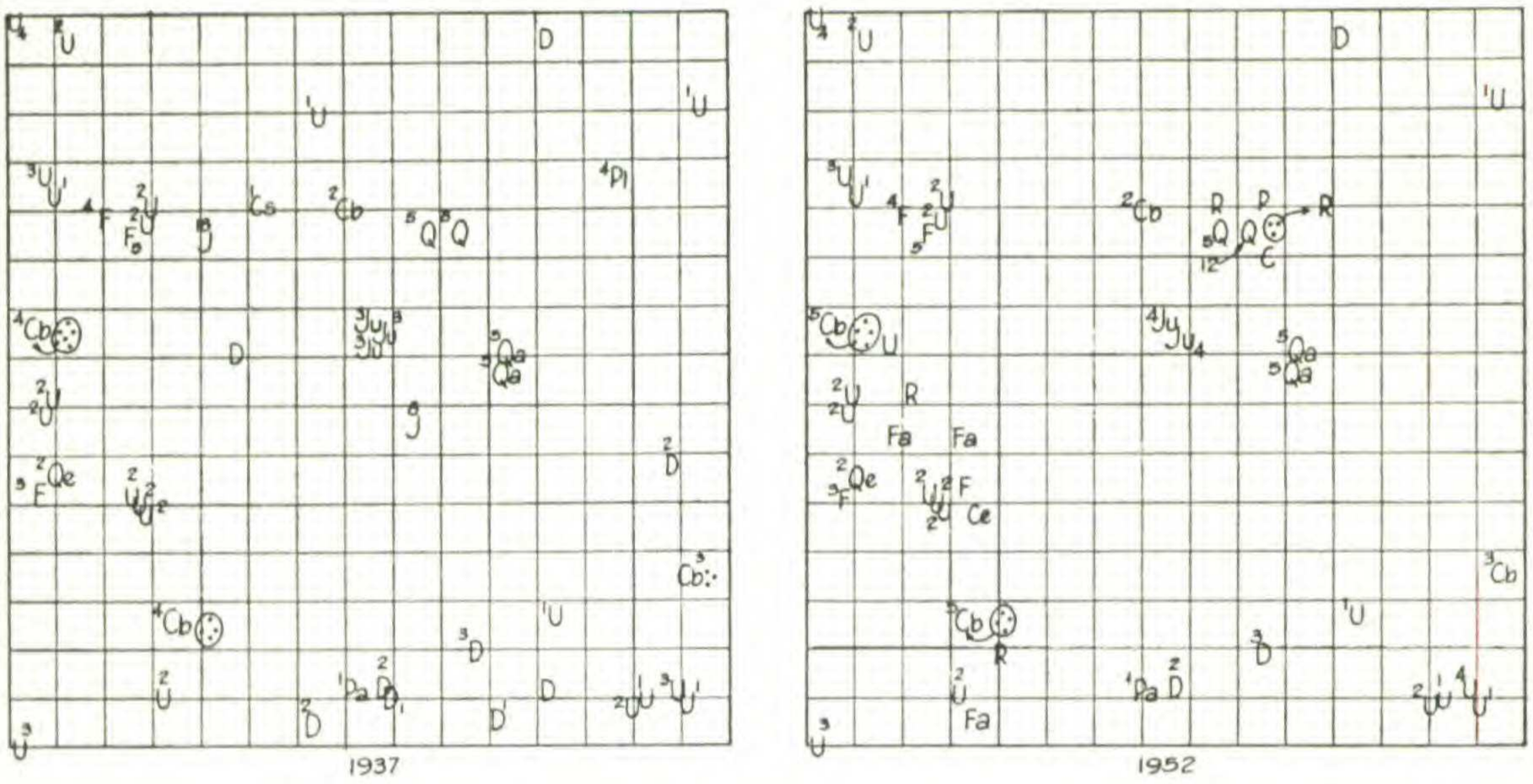

Fig. 1. Plots of a quadrat in the Oak Coppice Association for 1937 and 1952: Q = *Quercus alba*, C = *Carya ovata*, Cb = *Carya tomentosa*, Ca = *Cercis canadensis*, Co = *Cornus asperifolia*, D = *Diospyros virginiana*, F = *Fraxinus americana*, Fa = *Fraxinus quadrangulata*, J = *Juniperus virginiana*, Ju = *Juglans nigra*, P = *Prunus serotina*, Pa = *Prunus* sp., Pl = *Platanus occidentalis*, Qa = *Quercus imbricaria*, Qe = *Quercus velutina*, R = *Rhamnus caroliniana*, U = *Ulmus fulva*. Numerals indicate approximate diameter (DBH) to nearest inch.

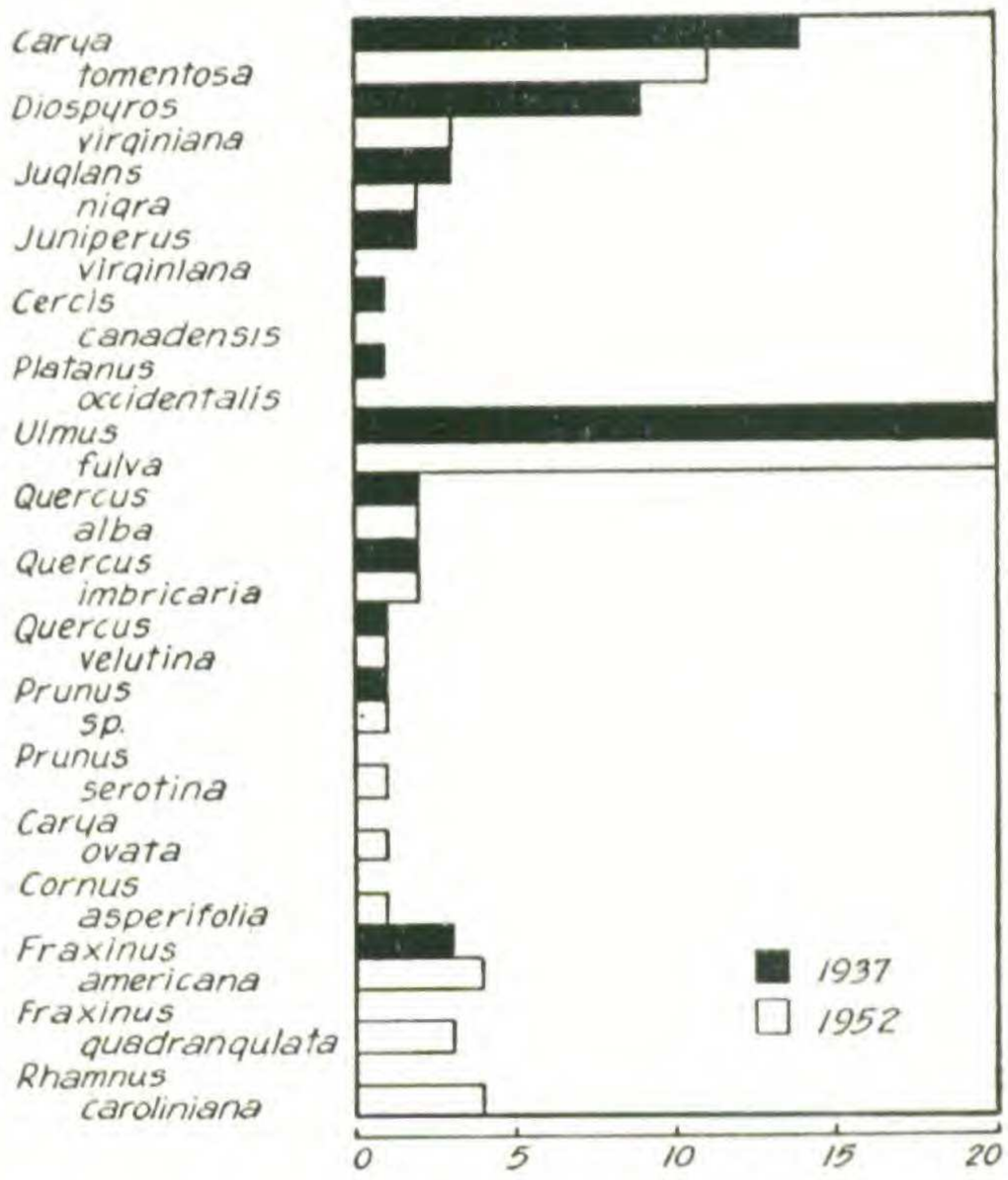

Fig. 2. Diagram representing relative numbers of plants of the species on a quadrat in the Oak Coppice Association in 1937 and 1952.

Recent inspection of the quadrat has revealed a great change in the growth habit of the forest trees. Now the White and Shingle Oaks, Mocker-nut Hickory, and Black Walnut have lost their lower limbs, their trunks are clean twelve to fourteen feet above the ground, and their crowns have developed more spread. The White Oak is still the dominant tree and has made considerable growth. Plants demanding large amounts of light, such as Redbud, Red Cedar, and Persimmon, have mostly been "shaded" out. At least one-fourth of the Persimmons have died and those remaining are in poor condition. The Slippery Elms are no less numerous, but the trees have grown very little. Some seedlings of Shagbark Hickory *(Carya ovata)*, White Ash *(Fraxinus americana)*, Blue Ash *(Fraxinus quadrangulata)*, Black Cherry *(Prunus serotina)*, and Rough-leaved Dogwood *(Cornus asperifolia)* have recently become established in the quadrat.

The record of this quadrat shows how quickly the forest species may become dominant and destroy an "open" aspect. The early land-use history of this area is not clear. It is believed that it had been pastured, and the numerous stump sprouts indicate that some pole-wood had been cut. Pasturing and the cutting of pole-wood promoted the rapid growth of light-loving plants such as Red Cedar, Redbud, and Persimmon, which formed a conspicuous part of the woody growth at the time of the first mapping of the quadrat. Since then and following a more conservative land-use program in which the area has not been pastured or burned, the forest trees have grown so vigorously as to dominate the quadrat area and "shade out" the light-loving plants. The many Slippery Elms, Persimmons, and

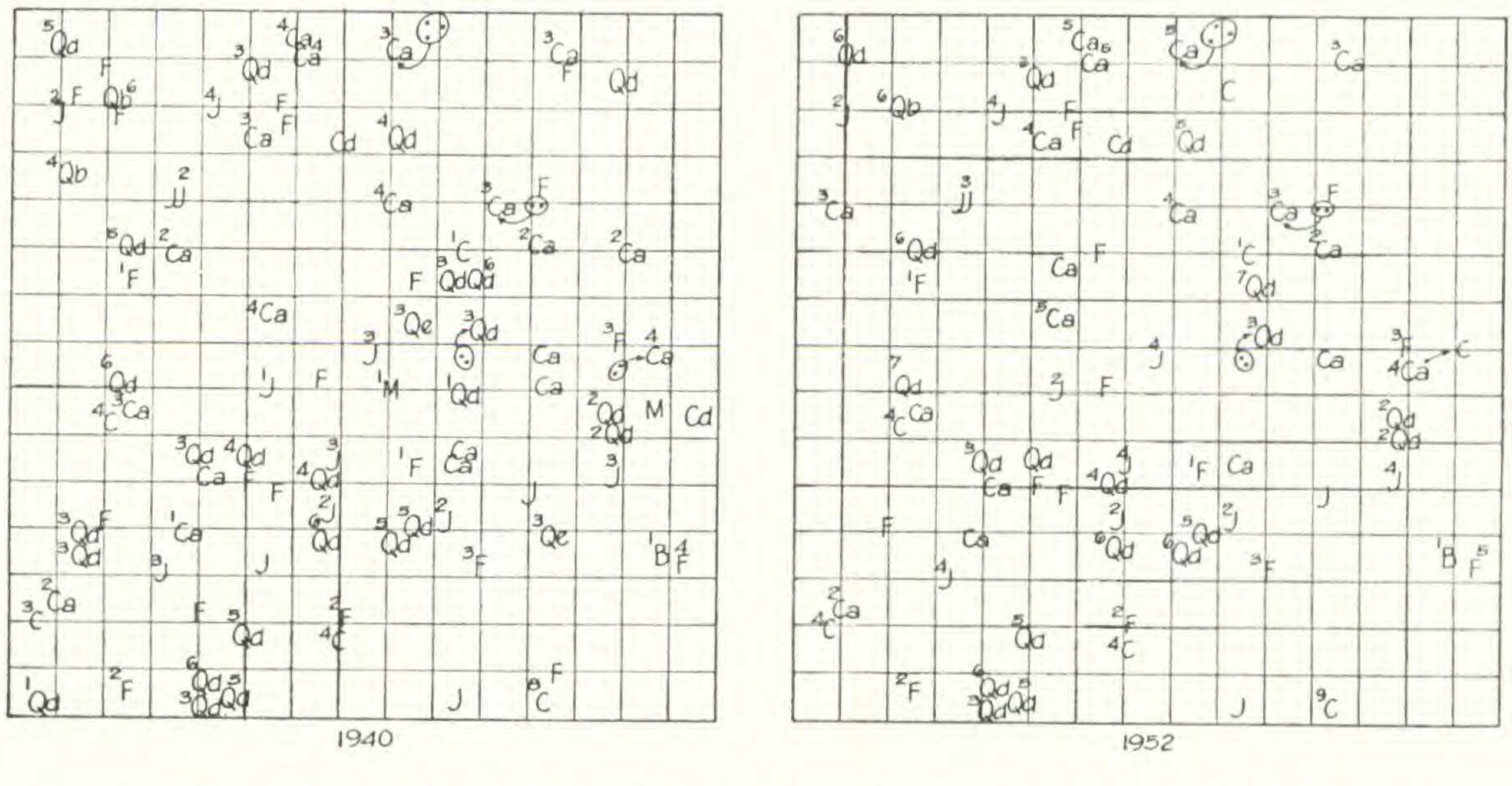

Fig. 3. Plots of a quadrat in the Oak-Hickory Association for 1940 and 1952: Am = *Amelanchier canadensis*, C = *Carya ovata*, Ca = *Carya Buckleyi*, Ce = *Celtis pumila*, F = *Fraxinus americana*, J = *Juniperus virginiana*, M = *Morus rubra*, Qb = *Quercus marilandica*, Qd = *Quercus stellata*, Qe = *Quercus velutina*.

Numerals indicate approximate diameter (DBH) to nearest inch.

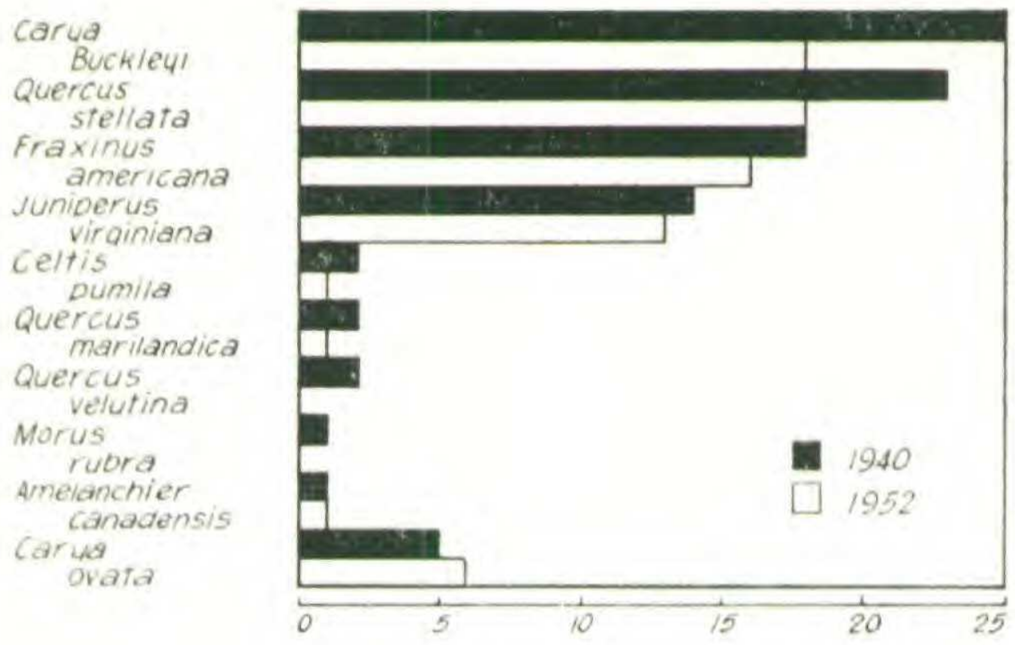

Fig. 4. Diagram representing relative number of plants of the species present on a quadrat in the Oak-Hickory Association in 1940 and 1952.

the Sycamore apparently germinated in the quadrat area about 1924 when it was set aside as a forest preserve. The grassy and otherwise herbaceous ground cover, so conspicuous at the time of the first mapping, has been replaced with duff of forest litter in which seedlings of Shagbark Hickory, White and Blue Ash, Indian Cherry, and Rough-leaved Dogwood have become established.

Quadrat in the Oak-Hickory (Quercus stellata-Carya Buckleyi) Association.—This quadrat (figs. 3 and 4) had been established in an oak-hickory forest just above a glade area. Here the Union Silt Loam overlays a somewhat massive phase of the Cotter Formation of dolomitic limestone. The early map shows small Post Oaks *(Quercus stellata)* and Pignut Hickory *(Carya Buckleyi)* as the dominant trees, and the Red Cedar *(Juniperus virginiana)* and White Ash *(Fraxinus americana)* were also numerous. Other species are mostly represented by seedlings.

The recent map indicates the continued dominance of the Post Oak and Pignut Hickory, but some of these trees have been lost in a natural thinning process. Many of the seedling trees have been lost, along with two large Black Oaks *(Quercus velutina)* and a Black Jack Oak *(Quercus marilandica)*.

The greater numbers of Red Cedar and the numerous seedlings on the early map indicate that more light entered the quadrat twelve years ago. This "open" aspect favored a lower branching habit of all the trees. Now the Post Oak and Pignut Hickory have made considerable growth and support well-developed crowns. They have lost many of their lower branches. Such a closing of the crown canopy has "shaded out" some of the Red Cedars and many seedlings of other trees.

Quadrat in the White Oak-Sugar Maple (Quercus alba-Acer saccharum) Association.—This quadrat (figs. 5 and 6) is located on a lower slope with a western exposure. The soil is the Union Silt Loam overlaying the basal sandstone phase of the Cotter Formation of rocks. The early map shows the White Oak as the dominant tree. The Sugar Maples, though not as large, were then of sufficient

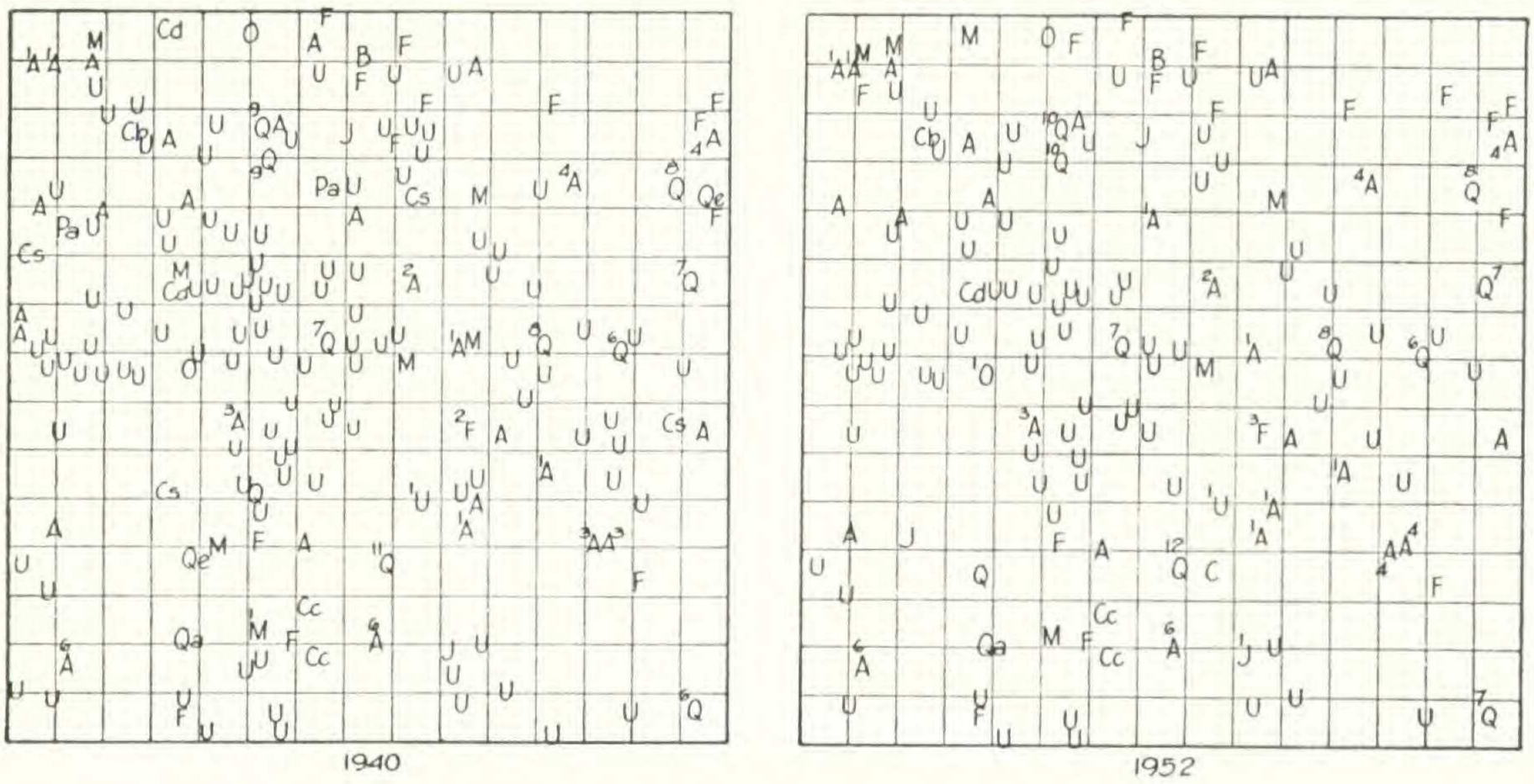

Fig. 5. Plots of a quadrat in the White Oak-Sugar Maple Association for 1940 and 1952: A = *Acer saccharum*, B = *Bumelia lanuginosa*, Cb = *Carya tomentosa*, Cd = *Celtis pumila*, Cs = *Cercis canadensis*, F = *Fraxinus americana*, J = *Juniperus virginiana*, M = *Morus rubra*, O = *Ostrya virginiana*, Pa = *Prunus* sp., Q = *Quercus alba*, Qu = *Quercus velutina*, U = *Ulmus fulva*.

Numerals indicate approximate trunk diameters (DBH) to the nearest inch.

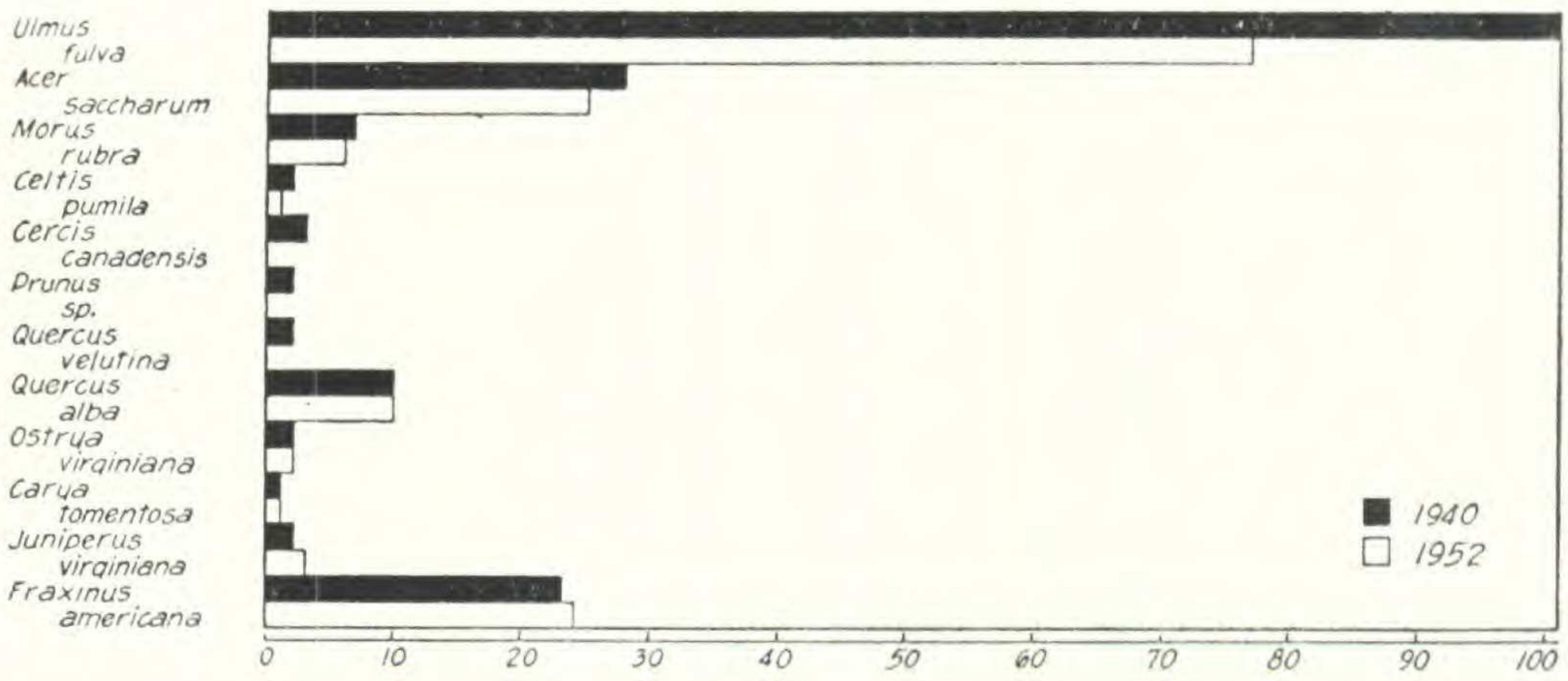

Fig. 6. Diagram representing relative numbers of plants of the species present on a quadrat in the White Oak-Sugar Maple Association.

size and vigor to suggest their co-dominance with the White Oaks. As shown in figs. 5 and 6, the seedlings of Slippery Elm *(Ulmus fulva)* were conspicuous at that time. It is also apparent that there was enough light entering the area to support several Redbuds *(Cercis canadensis)*, as well as Red Cedar *(Juniperus virginiana)*, Dwarf Hackberry *(Celtis pumila)*, and Red Mulberry *(Morus rubra)*. A single Hop-Hornbeam *(Ostrya virginiana)* was thriving.

Recent inspection of the quadrat shows that the White Oak continues to be dominant and that the trees have made appreciable growth. The Sugar Maple is growing slowly and is being suppressed by the White Oak. At least 20 per cent of the Slippery Elm seedlings have been lost and those remaining have made no

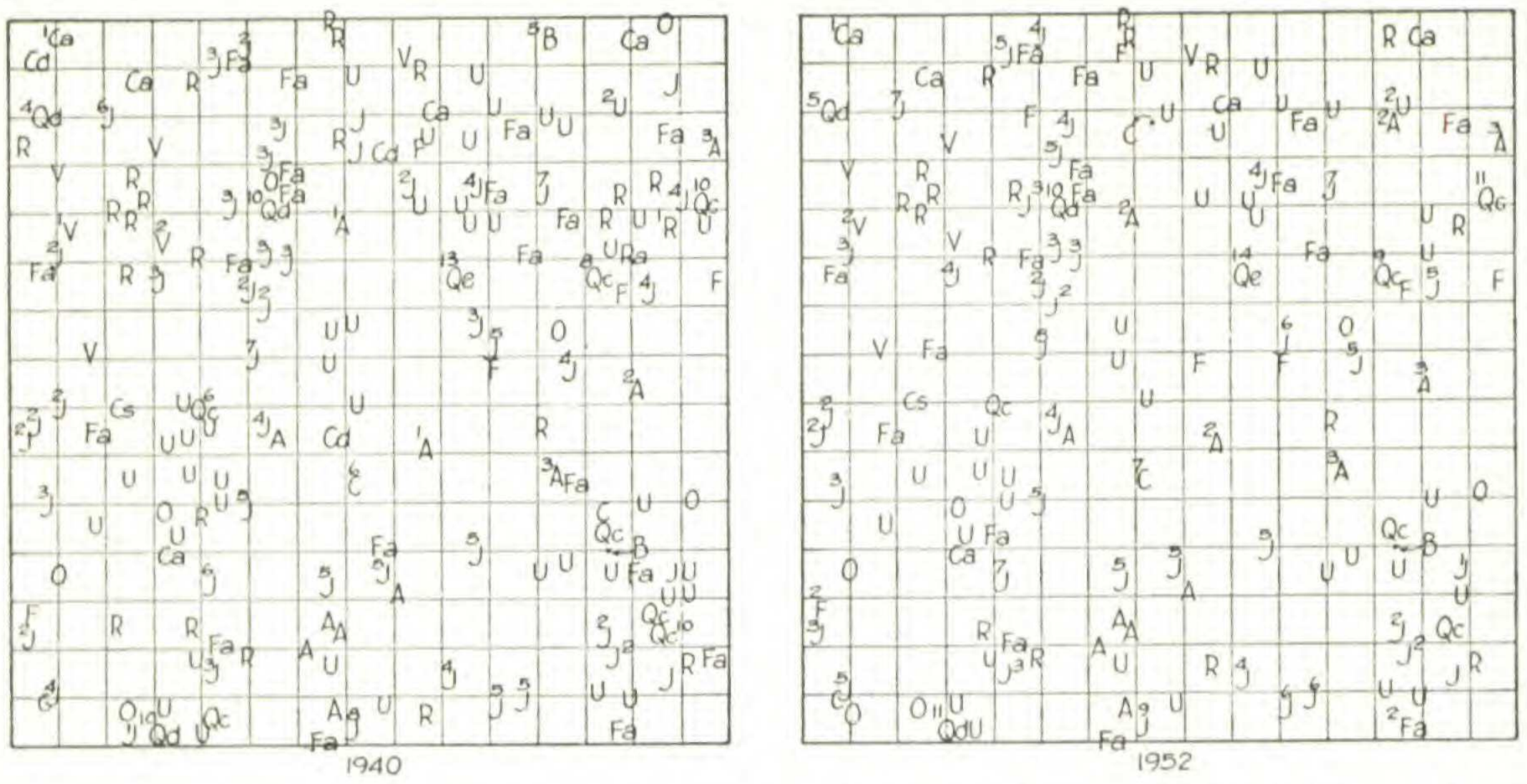

Fig. 7. Plots of a quadrat in the Red Cedar-Chinquapin Association for 1940 and 1952: A = *Acer saccharum*, Am = *Amelanchier canadensis*, B = *Bumelia lanuginosa*, C = *Carya ovata*, Ca = *Carya Buckleyi*, Cd = *Celtis pumila*, F = *Fraxinus americana*, Fa = *Fraxinus quadrangulata*, J = *Juniperus virginiana*, O = *Ostrya virginiana*, Qc = *Quercus Muhlenbergi*, Qd = *Quercus stellata*, Qe = *Quercus velutina*, R = *Rhamnus caroliniana*, Ra = *Rhamnus lanceolata*, U = *Ulmus fulva*, V = *Viburnum rufidulum*.

Numerals indicate approximate trunk diameters (DBH) to the nearest inch.

noticeable growth. The Redbud, Red Mulberry, and Dwarf Hackberry have suffered from reduced light brought about by the expanding crowns of the White Oaks. Red Cedars, though as frequent, have made but little growth and are in poor condition.

The occurrence of old stumps in the area about the quadrat indicates that some trees had been cut prior to the first mapping. Such cutting probably permitted the entrance of enough light to encourage growth of Redbud, Mulberry, Dwarf Hackberry, Red Cedar, and the many seedlings of Slippery Elm. It also may have brought about increased growth of the remaining White Oaks which have become entirely dominant at the expense of the Sugar Maples and seedling trees.

Quadrat in the Red Cedar-Chinquapin Oak (Juniperus virginiana-Quercus Muhlenbergi) Association.—This quadrat (figs. 7 and 8) is located on a lower slope with a western exposure. The soil is very shallow and lies immediately upon the somewhat massive phase of the Cotter Formation of rock. The early map shows a considerable number of Red Cedars 4–7 inches in diameter and a number of Chinquapin Oaks of comparable size. These two species were the dominant trees of the quadrat. Also present were two large Post Oaks *(Quercus stellata)*, a Black Oak *(Quercus velutina)*, and a single large Chittimwood *(Bumelia lanuginosa)*. At that time the quadrat had a "brushy aspect", with Slippery Elm *(Ulmus fulva)* making the greater part of the undergrowth, and in less abundance Redbud *(Cercis canadensis)*, Indian Cherry *(Rhamnus caroliniana)*, Hop-Hornbeam *(Ostrya virginiana)*, Dwarf Hackberry *(Celtis pumila)*, Lance-leaved Buckthorn *(Rhamnus lanceolata)*, Shadbush *(Amelanchier canadensis)*, and Black Haw

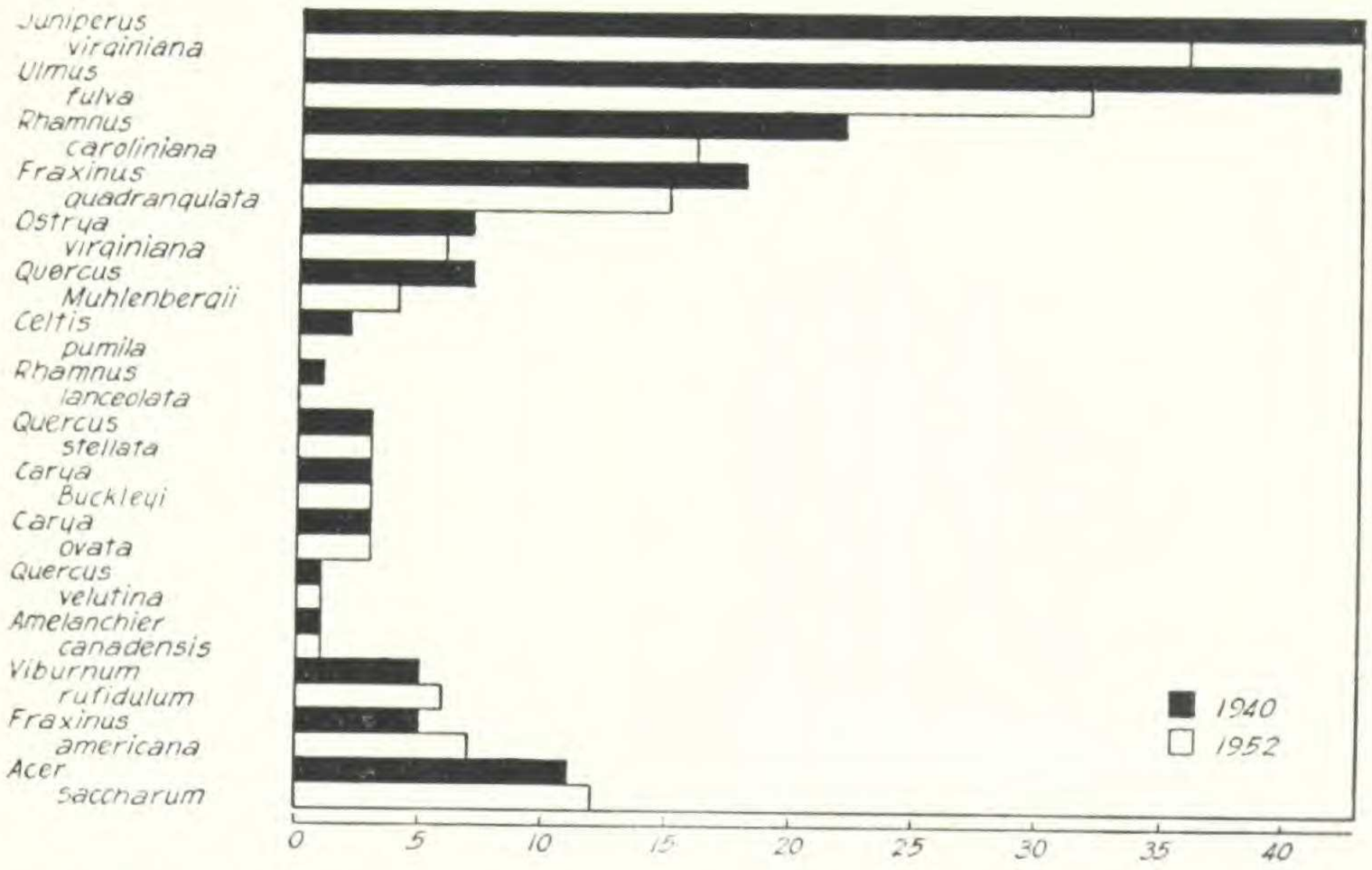

Fig. 8. Diagram representing relative numbers of plants of the species present on a quadrat in the Red Cedar-Chinquapin Oak Association for 1940 and 1952.

(Viburnum rufidulum). There were also seedlings of Blue Ash *(Fraxinus quadrangulata)*, White Ash *(F. americana)*, and small trees of Sugar Maple *(Acer saccharum)*.

The recent survey of the quadrat shows that about one-sixth of the Red Cedar trees were lost through competition and that the ones left had grown considerably. Some Chinquapin Oaks had also died but the remaining trees had made some growth. There was no change in the number of oaks and hickories and they also have grown. The single large Chittimwood has died. The greatest change is in the understory growth. Almost a fourth of the Slippery Elms have died and those left have scarcely grown either in diameter or height. Other understory trees as Indian Cherry and Hop-Hornbeam are less frequent but are growing vigorously. Lance-leaved Buckthorn and Dwarf Hackberry have died. There are a few more trees of Shadbush and Black Haw and they are thriving. The number of White Ash and Sugar Maple trees has increased slightly, but their seedlings and small trees are growing slowly. The Blue Ash, present mostly as small and seedling trees, has decreased in number, although the plants remaining are making moderate growth.

On this and the preceding quadrats, many specimens of Slippery Elm, White Ash, Red Cedar, Post Oak, Pignut Hickory, and Sugar Maple are only 4–5 feet in height. On casual inspection they give the appearance of young plants but actually they are 15–20 years old.

OBSERVATIONS ON FOREST SUCCESSION

Time-lapse studies presented in the foregoing forest quadrats and in the more general association maps in an earlier paper[3] have revealed significant facts concerning forest succession for the area under consideration. The conclusions reached for the local area may have a wider application for the Ozark region in general. One of the outstanding features brought out by this study has been the marked inability of most species to invade established associations except in the event of a catastrophe such as fire, lumbering, heavy pasturage, or abrupt changes in climate of considerable duration.

In the four quadrats described the invasion and decline of numerous seedlings have been observed. With almost no exceptions species have been able to invade established associations and to demonstrate vigor sufficient to suggest the possibility of their offering serious competition to established trees. It was found that the greater number of seedlings of species mentioned in the foregoing quadrat reports originated in the years following a major catastrophe, in this case the drought period of 1930–1936, which seriously weakened the trees in the region of the Arboretum Forest Preserve. During the time lapse of this study it has been observed that the existing associations continue in their "catastatic" state. Historical data indicate that a catastrophe will incite germination of seeds and start successful invasion of the disturbed association.

In any event, the association will be a happenstance entirely dependent upon the kind of seed immediately available and the peculiar requirements both for germination and survival of the seedlings. Even though the seedlings may survive and reach maturity they may not represent the best-adapted species for the site. However, no other species with similar requirements for germination were present at the time that the site was a frontier ready for invasion. Those plants surviving to seed-producing maturity will then become conspicuous in the forest association. It is believed that such species may often so completely occupy the site, filling shallow soils with roots and shading the soil surface with their tops, as to prohibit or retard seedling growth. The invasion of new plants in this established local association is thus prevented, and the association may be perpetuated for many generations and cover considerable areas. Plants unsuited for a particular site are often short-lived, as illustrated by the many forest trees used in landscape planting which mature early and become an easy victim of minor accidents. If the association is weakened, it will be vulnerable to seedling invasion. Better-adapted species may then enter if seed sources are adequate, or, lacking this condition, the growth of seedlings will comprise a regeneration of the existing association.

The Blue Ash *(Fraxinus quadrangulata)* has offered an excellent opportunity to study invasion as related to seed source. The early history of the area has shown that many Blue Ash trees had been cut for fire-wood and for farm-implement manufacture. When the Forest Preserve was established there were few trees of Blue Ash. Almost no seedlings were to be found in the Forest Preserve, but now many Blue Ash trees are fruiting abundantly, and the seedlings are invading adjacent open areas.

[3] Beilmann and Brenner, op. cit.